Plant Pathology Circular No. 257
March 1984

Fla. Dept. Agric. & Consumer Serv.
Division of Plant Industry

SULFUR DIOXIDE INJURY TO PLANTS

T. S. Schubert

Air pollutants are becoming increasingly common causes of abiotic plant diseases. Symptoms of plant injury due to an air pollutant are usually characteristic of the specific pollutant and the plant species involved. Pollutants normally undergo a chemical transformation in the process of injuring plant tissue, therefore symptoms are the main evidence used in diagnosis. Other considerations which must be taken into account in the diagnosis are: (1) identification of a probable source of the pollutant; (2) identification of all the symptomatic plant species in the vicinity; (3) gradation of symptoms (decreasing severity with increasing distance from suspected source); (4) atmospheric conditions prevailing during exposure; (5) other possible biotic and abiotic causal agents which could mimic or contribute to symptoms. In many cases, suspicious incidents of air pollution injury to plants can never be proven positively, even though much circumstantial evidence can be gathered.

Sulfur dioxide (SO_2) is the most thoroughly studied air pollutant damaging to plants. This pollutant enters the atmosphere during the combustion of fossil fuels, especially high-sulfur coal and petroleum. Manufacture of paper pulp by the Kraft (sulfite) process also releases SO_2, (5). Roasting and smelting of metal ores, natural gas purification, oil refining, sulfuric acid manufacture, and volcanic activity, though not important in Florida, can release significant amounts of SO_2, into the atmosphere. Injury to vegetation should be confined to the vicinity of the source, although the combination of SO_2 with atmospheric moisture produces sulfuric acid precipitation, which can have geographically widespread consequences.

Sulfur dioxide concentrations in unpolluted air measure less than 0.05 ppm. Large urban areas can expect SO_2 levels ranging from 0.05-0.4 ppm about 10% of the time (4). Smelters or coal burning power plants not fitted with operational pollution control devices can increase SO_2 concentrations to 1-3 ppm. Human health standards are set at 0.03 ppm average daily exposure on a yearly basis with 0.14 ppm maximum exposure during a 24 hour period (1). Plants generally do not show symptoms of SO_2 injury until human health standards have been exceeded.

SYMPTOMS. Plants acutely injured by SO_2 display necrotic, usually bleached white to tan tissues between leaf veins, while veins themselves remain green (Fig. 1). Chronic lower doses of SO_2 may cause chlorosis rather than necrosis of interveinal tissues (2,3). Pollutant dose (i.e., duration of exposure X concentration of pollutant), which is moderated by many biological and meteorological factors, determines the severity of damage (4). Evidence of SO_2 injury is restricted to leaves.

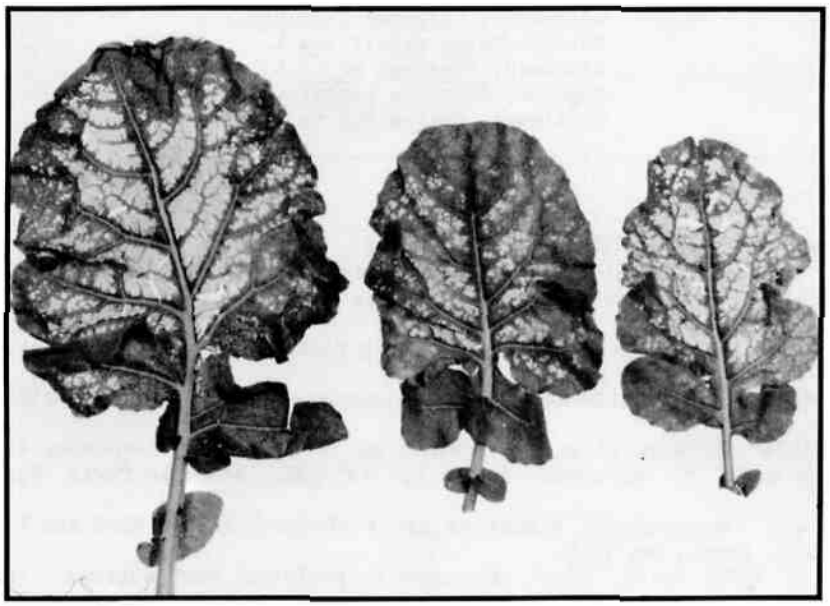

Fig. 1. Symptoms of acute SO_2 injury to broccoli foliage.

Sulfur dioxide is often accompanied by other air pollutants in urban areas, especially ozone. Synergism between air pollutants has been demonstrated (7), so symptoms can be confusing. Furthermore, some pollutants acting alone, namely peroxyacetyl nitrate (PAN), nitrogen dioxide (NO_2), chlorine (Cl_2), and hydrochloric acid fumes (HCl), can cause symptoms similar to those of SO_2 injury (2). To determine which air pollutants might be responsible for a particular incident, one must examine a number of different plant species in the vicinity.

PLANTS SENSITIVE TO SULFUR DIOXIDE: Table 1 lists some representative Florida plants which are injured by SO_2 levels of 0.05-0.5 ppm SO for 8 hours, or 1-4 ppm for about 30 minutes. Such plants are considered relatively sensitive to SO_2 (6). In contrast, relatively resistant plants would require dosages of 2 ppm SO_2 for 8 hours or 10 ppm for 30 minutes.

[1]Plant Pathologist, Bureau of Plant Pathology, P. 0. Box 1269, Gainesville, FL 32602.

It is important to note that plants vary widely in their sensitivity to SO_2, even within a plant species. Sulfur dioxide must enter stomata into mesophyll tissue to injure leaves. If stomata are closed because of water stress or other causes, susceptible plants may escape injury, even though exposed to high SO_2 levels. Also, plant age can markedly affect certain species sensitivity to SO_2.

SURVEY AND DETECTION: Look for SO_2 sensitive plants (see table) displaying necrotic or chlorotic interveinal areas. Symptomatic plants should be in the vicinity of a suspected SO_2 source. Bioindicator plants which are particularly useful for detection of SO_2 in the atmosphere are (8): Medicago sativa L. 'Du Puits', Trifolium incarnatum L., Pisum sativum L., Fagopyrum esculentum Moench., and Plantago major L.

Table 1. Plants Sensitive to SO_2.

Field Crops	Vegetables
Alfalfa, Medicago sativa L.	Bean, Phaseolus vulgaris L.
Barley, Hordeum vulgare L.	Broccoli, Brassica oleracea L., Botrytis Group
Bean, Phaseolus sp.	Brussel sprouts, Brassica oleracea L., Gemmifera Group
Clover, Trifolium sp.	Carrot, Daucus carota L. var. sativus Hoffm.
Cotton, Gossypium sp.	Endive, Cichorium endivia L.
Oats, Avena sativa L.	Lettuce, Lactuca sativa L.
Rye, Secale cereale L.	Okra, Hibiscus esculentus L.
Soybean, Glycine max Merr.	Pea, Pisum sativum L.
Sweet clover, Melilotus sp.	Pepper, Capsicum frutescens L.
Wheat, Triticum sp.	Pumpkin, Cucurbita pepo L. var. pepo
Flowers	Radish, Raphanus sativus L.
Cosmos, Cosmos bipinnatus Cav.	Squash, Cucurbita maxima Duchesne
Four o'clock, Mirabilis jalapa L.	Sweet potato, Ipomoea batatas (L.) Lam.
Morning-glory, Ipoemoea purpurea (L.) Roth.	Swiss chard, Beta vulgaris L., Cicla Group
Sweet pea, Lathyrus odoratus L.	Turnip, Brassica rapa L., Rapifera
Violet, Viola sp.	
Zinnia, Zinnia elegans Jacq.	
Trees Group	
American elm, Ulmus americana L.	
Apple, Malus sp.	Weeds
Pear, Pyrus comminus L.	Buckwheat, Fagopyrum esculentum Moench
River birch, Betula nigra L.	Curly dock, Rumex crispus L.
Western catalpa, Catalpa bignonioides Walt.	Horseweed, Erigeron canadensis L.
	Mallow, Malva parviflora L.
	Plantain, Plantago major L.
	Ragweed, Ambrosia artemisiifolia L.
	Sunflower, Helianthus sp.

LITERATURE CITED.

1. "Air Pollution," New Funk and Wagnells Encyclopedia, 1983. Vol. 1:278-281.
2. BARRETT, T. S., and H. M. BENEDICT. 1970. Sulfur dioxide. In "Recognition of Air Pollution Injury to Vegetation" (J. S. Jacobson and A. C. Hill, eds.), pp. C1-C17. Air Pollution Control Association, Pittsburg, PA.
3. DARLEY, E. F., and J. T. MIDDLETON. 1966. Problems of air pollution in plant-pathology. Ann. Rev. of Phytopathol. 4:103-118.
4. HEAGLE, A. S. 1973. Interactions between air pollutants and plant parasites. Ann Rev. of Phytopathol. 11:365-388.
5. MILLER, P. R., and J. R. McBRIDE. 1975. Effects of air pollutants on forests. In "Responses of Plants to Air Pollution" (J. B. Mudd and T. T. Kozlowski, eds.), pp. 195-235. Academic Press, New York.
6. MUDD, J. B., 1975. Sulfur dioxide. In: "Responses of Plants to Air Pollution" (J. B. Mudd and T. T. Kozlowski, eds.), pp. 9-22. Academic Press, New York.
7. REINERT, R. A., A. S. HEAGLE, and W. W. HECK. 1975. Plant responses to pollutant combinations. In "Responses of Plants to Air Pollution" (J. B. Mudd and T. T. Kozlowski, eds.), pp. 159-177. Academic Press, New York.
8. STEUBING, L., and H.-J. JAGER. 1982. Monitoring of air pollutants by plants: methods and problems. Dr W. Junk Publishers, Hague, Netherlands, p. 163.

Contribution No. 559, Bureau of Plant Pathology.